Context, prediction, and individual differences: Roles in shaping memory

Honors Research Thesis

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by

Alexis Wagner

The Ohio State University

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Project Advisor: Professor Per Sederberg, Department of Psychology

Abstract

Throughout our lives, we experience a constant stream of events. The emotions we feel as a result of each event is a product of multiple factors, including the context in which the event occurs, our predictions of the event, and individual differences, such as personality and time perspective biases. The relationships between these factors are numerous and multi-directional. For example, while context, prediction, and personality influence how we remember events, our memories of events in turn shape our personalities and future predictions. This cyclical relationship could indicate a role of memory in mood disorders, such as depression. For example, people high in the personality trait neuroticism may be predisposed to remember even neutral stimuli as being negatively valenced if the stimuli are situated in certain emotional contexts. They may also be more likely to make negative predictions and to have a past-negative time perspective, meaning they are biased to focus on the past in a negative manner. This could cause this population of people to be more susceptible to mood disorders since they are be stuck in a pessimistic feedback loop. Therefore, the interactions between context, prediction, and individual differences in the processing of emotional and neutral stimuli are an important area of investigation.

Background

Our lives consist of a constant stream of events, some positive, some negative. Consider the following sequence of events: over the course of the past few weeks, everything has been going wrong. First, your car was stolen, then you lost your job, and, today, you fractured your ankle. Now, consider another sequence of events. You recently won a new car and secured your dream job. Today, you fractured your ankle. Although the final event in both of these sequences is the same, the resulting emotion is likely different since emotion is a product of affective contexts. According to models of emotional processing, such as the Iterative Reprocessing model, emotions are formed by comparing our past

affective state to our present state (Cunningham & Zelazo, 2007). Therefore, a negative event, such as fracturing one's ankle, is not expected to be perceived as negatively if it follows a succession of negative events as it would be if it occurred in stark contrast to a stream of positive events.

Past research has indicated the formation of an emotion is not an isolated event. Instead, emotions form as a result of the ever-changing contexts in which life events occur (Kirkland & Cunningham, 2011a). However, despite the continuous nature of life, many experimental studies continue to investigate emotion through isolated stimuli (Kirkland & Cunningham, 2011b). When an event occurs, our emotional response is shaped by not only our current experience, but also the past and our predictions of the future (Kirkland & Cunningham, 2011b). The influence of temporal context can be seen even in the words we use to describe emotions. For example, the word hope is used to describe the feeling of currently being in a negative situation but predicting a positive future state (Kirkland & Cunningham, 2011a).

In addition to influencing the emotions we feel, past experiences also shape the way in which we remember events. As stated by Mather (2007), "most research on emotional memory in humans has focused on item memory rather than on memory for context or associations" (p. 33). Item-by-item analyses limit the applicability of emotional memory research to everyday life, in which items always reside within a context. When context is considered in affective memory research, emotional events have been shown to enhance the memory of neutral events that precede them. This selective memory enhancement was shown to be due to the arousing stimuli's facilitation of memory consolidation for contiguous stimuli (Anderson, Wais, & Gabrieli, 2006). However, when neutral stimuli come to be known as predictors of emotionally arousing stimuli, memory for contextual details of the neutral stimuli is diminished (Mather & Knight, 2008). Thus, both our memory of the past and our predictions of the future influence the way in which we process both emotional and neutral stimuli.

As shown by Kirkland and Cunningham, context plays a key role in how we experience emotions, as evidenced by our selection of emotion labels (2011a). Therefore, it would be remiss for theories of

emotional processing to not include context. One theory, the Iterative Reprocessing (IR) model, addresses the importance of context, prediction, and individual differences. In this model, contextual information is incorporated through the reprocessing of stimuli (Cunningham & Zelazo, 2007). Contextual information is important because it can affect how a stimulus is perceived. In addition to the unconscious processing detailed in the IR model, the reprocessing of stimuli is evident in conscious processes, such as cognitive reappraisal of emotions, which involves the purposeful use of techniques to modify the degree and/ or type of emotion experienced (Gross, 2001).

The IR model's emphasis on context is in contrast to other models, including the Dual Attitudes model. According to this model, people have two independent attitudes: implicit and explicit. Implicit attitudes are automatic and cannot be changed even if the explicit attitude is altered, while the explicit attitude can be changed via top-down cognitive control (Wilson, Lindsey, & Schooler, 2000). However, this model only considers people's responses to individual stimuli. Accordingly, it is unable to assess changes that occur as a result of context.

Context plays an integral role in both selecting and processing salient information. However, context is perceived differently by different people due to individual differences in constructs such as personality. These differences could be the manner in which individual dispositions form or could be the result of a pre-existing outlook on life. Individual differences in the selection of salient information has clinical implications in disorders such as depression. People with depression have been shown to selectively attend to negative stimuli in studies using faces (Joormann & Gotlib, 2007) and words (Bradley, Mogg, & Lee, 1997). Additionally, this bias is seen both after remission of depressive symptoms (Joormann & Gotlib, 2007) and in never-depressed first degree relatives of people with depression (Murrough, Iacoviello, Neumeister, Charney, & Iosifescu, 2011), indicating a bias toward negative stimuli may predispose people to being more likely to develop depression. Accordingly, the amelioration of this cognitive bias is one of the primary goals of cognitive therapies (Beck, 1988).

As demonstrated by cognitive therapies, attentional biases can be altered. This can be accomplished by increasing the accessibility of positive information, through methods such as priming (Smith, et al., 2006). Priming, which refers to pre-exposure to stimuli of a particular class, results in information similar to the primed stimuli being more accessible. Priming is similar to mood congruent information processing except that its effects are transitory. Mood congruent processing refers to our preference toward stimuli that fit our current mood (Rusting, 1998). For example, a dejected person directs more of their attention to negative aspects of their environment than to positive aspects. A more long term version of mood congruency is trait congruent processing. In this type of information processing, we seek out stimuli that match our personality traits (Rusting, 1998). Since personality is more stable than mood, this type of processing has a greater impact on selecting the events to which we attend throughout our lives.

In addition personality, another source of individual differences in the processing of salient stimuli is time perspective, which refers to biases to focus on the past, present, or future. Both time perspective and personality traits play key roles in determining what types (i.e. what emotional valences) of information to which we attend. People with depression and anxiety tend be past-focused, which manifests itself in the worry and rumination present in people with these disorders (Nolen-Hoeksema, 2000). As a personality trait intimately linked with both anxiety and depression, neuroticism is also associated with past-focused attention (Stein, 2009; Shipp, Edwards, & Lambert, 2009).

Similar to context, our temporal focus can be reflected in the words we use to characterize our emotions. Different emotion descriptors are used depending on whether we are focusing on the past, present, or future. For example, while we are in a positive state but predict a negative future, two emotional descriptors can be used: hope and fear. Hope is experienced when one ignores the prediction, instead choosing to focus on the present. Conversely, the feeling of fear reflects a bias to focus on the prediction of the future negative event (Kirkland & Cunningham, 2011a).

In addition to context and individual differences, prediction also plays a key role in selecting which items are processed and how these items are later remembered. This is evidenced by the finding that people who are deficient in making predictions also show deficits in attention and working memory (Bechara et. al, 1996). Not only does the prediction itself influence how information is later remembered, whether or not the prediction is later proven correct also matters. For example, as shown by Kirkland and Cunningham, if the present state is positive but the predicted future state is negative, different emotions could result depending on the validity of the the prediction (2011a). If the prediction proves to be correct, the resulting emotions would likely include sadness. However, if the prediction is not correct, the emotion experienced could instead be anger (Kirkland & Cunningham, 2011a). These differences can be viewed in reference to the aforementioned anecdote of fracturing one's ankle. If one expected to have a negative experience and was proven correct by virtue of the injury occurring, the expected emotion would be sadness. If one instead predicted a positive experience but was injured, the resulting emotion would instead be anger.

As the body of literature indicates, context, prediction, and individual differences all play key roles in the generation of emotions. However, previous research has failed to examine how these factors interact with each other. Many studies present participants with individual images, thus not allowing a context to form (Ochsner, Bunge, Gross, & Gabrieli, 2002; Anderson, et al., 2005). Others do present stimuli within contexts but do not assess individual differences, such as personality (Kirkland & Cunningham, 2011a; Mather & Knight, 2008). Moreover, participants need to be able to make predictions based off their experiences (Hampton, Adolphs, Tyszka, & O'Doherty, 2007; Schwarz, 2000). A study so designed would most closely mimic real-life, in which stimuli reside within contexts, can be used to make predictions, and are processed differently depending on each person's unique outlook.

Introduction

The goal of the present study was to incorporate aspects of real-life, including individual

differences, into the study of how emotional stimuli affect neutral ones. The two measures of individual differences utilized in this study were a measure of personality and one of time perspective. The purpose of including these measures was to assess the effect of individual differences in determining the salience of stimuli. For example, will a person high in neuroticism preferentially attend to negative stimuli?

Personality

There is a bidirectional relationship between our personalities and how we perceive stimuli. While our personalities influence how events are perceived, events simultaneously shape our personalities. In this study, individual personality differences were assessed via the Big Five Aspect Scale, which was chosen because it has been established as a reliable measure of predicted reactions to encountered stimuli (BFAS: DeYoung, Quilty, & Peterson, 2007). While the BFAS consists of five traits, the two traits of interest in this study were neuroticism and openness. Within these broad traits, there are two narrower aspects. In neuroticism, these are withdrawal and volatility. The openness trait divides into openness and intellect. The version of the BFAS that only includes the traits openness and neuroticism is referred to as the BFAS-ON, which can be found in Appendix A.

Neuroticism

The neuroticism subscale of the BFAS-ON is negatively correlated with personality traits such as stability, calmness, and happiness. The volatility aspect of neuroticism is especially negatively correlated with traits such as impulse control. Characteristics seen in people high in volatility include irritability, anger, and emotional impulsiveness. The other aspect of neuroticism, withdrawal, is highly negatively correlated with happiness. People high in withdrawal often exhibit negative affect (DeYoung et al., 2007) and neuroticism as a whole is negatively correlated with inventories of happiness (Furnham & Petrides, 2003).

Although both groups tend to show heightened reactivity to negative stimuli, there are differences between those high in volatility and those high in withdrawal (Canli, et al., 2001; Van Doorn & Lang, 2010). People high in withdrawal show a general avoidance of stimuli, regardless of valence, in a

persistent attempt to avoid negative events. Conversely, people high in volatility are hypersensitive to cues of impending negative events and take action once such an event occurs (Cunningham, Arbuckle, Jahn, Mowrer, & Abduljalil, 2010).

Openness

In contrast to neuroticism, the openness trait of the BFAS-ON is positively correlated with attributes such as imagination, creativity, and ingenuity. As aforementioned, openness divides into two aspects: openness and intellect. The openness aspect is marked by an interest in aesthetics and reflection. The intellect aspect is associated with creativity, quickness, and high intellect (DeYoung et al., 2007). The overall openness trait is positively correlated with measures of happiness (Furnham & Petrides, 2003).

Time Perspective

In addition to personality, we were also interested in individual differences in time perspective, as assessed by a short form of the Zimbardo Time Perspective Inventory (ZTPI: Zimbardo & Boyd, 1999). This form can be found in Appendix C. The ZTPI includes five factors: past-negative, past-positive, present-hedonistic, present-fatalistic, and future. People who rate highly in the past-negative factor tend to dwell on the past and view it in an unfavorable manner (Zimbardo & Boyd, 1999). In relation to the aforementioned BFAS-ON, the past-negative dimension of the ZTPI is positively correlated with neuroticism (Shipp, et al., 2009). Therefore, this group of people could be expected to both selectively attend to the past and to negatively ruminate upon it. People high in the past-positive factor also tend to focus on the past, but they view it in a warm and favorable manner (Zimbardo & Boyd, 1999).

Conversely, present-hedonistic and present-fatalistic people tend to focus on the present rather than the past. Those high in the present-hedonistic factor are primarily concerned with having pleasure in the present moment and will take risks to attain such pleasure (Zimbardo & Boyd, 1999). The present-hedonistic factor of the ZTPI is positively correlated with the openness trait of the BFAS-ON (Shipp, et al., 2009). People high in the present-fatalistic factor also focus on the present but do so because

they feel they have little control over the future and, therefore, have no reason to attempt to predict it. People who rate highly in the fifth factor of the ZTPI, future, tend to be goal-oriented and focus on future outcomes rather than the past or present (Zimbardo & Boyd, 1999).

Goals of Study

The overarching goals of the study are to investigate the roles of context, prediction, and individual differences. The interaction between these three items plays a key role in how we process and characterize information we encounter in everyday life. Our predictions of upcoming stimuli are based off of contextual information and are shaped by our personalities. Additionally, our personalities can play a role in what contexts we encounter and about which stimuli predictions are made.

Context

Context, in the form of emotional images surrounding a neutral image, was expected to alter how participants processed and later remembered neutral stimuli. In this study, there were four possible contexts, or valence trajectories, of interest: positive-positive, positive-negative, negative-positive, and negative-negative. The contexts will be referred to according to the valence of the images that appeared before and after the neutral images. For example, a neutral stimulus appearing in a positive-positive trajectory was both preceded and followed by positive images. We expected these valence trajectories to interact with personality and time perspective in determining which emotions and valences were later associated with the neutral stimuli, as well as recognition of the neutral stimuli.

Items appearing in a positive-positive trajectory were expected to be rated positively and assigned the emotion happiness. Neutral images situated in a negative-positive context were also expected to be rated positively, but more strongly, and assigned the emotion hope. These stimuli were expected to be rated more highly than the positive-positive images since they signaled a transition from negative to positive items. Hope was the expected emotion since these neutral images were a sign of positive images to come. However, for this to occur, participants must have focused on the positive prediction rather than

the negative present.

In contrast, neutral stimuli that appeared in a negative-negative trajectory were expected to be rated negatively and to be associated with sadness. Items shown in a positive-negative trajectory were expected to be rated negatively and to be associated with anxiety since they signaled negative images to come. Since these images signaled a negative change in context, they were expected to be rated even more negatively than the negative-negative stimuli.

Prediction

Prediction was employed in the present study through the repeated presentation of neutral stimuli within the aforementioned emotional contexts. Each time a neutral image was repeated, it occurred in the same valence trajectory. For example, if a neutral image appeared after negative images and before positive images, it always appeared after negative images and before positive ones. Since the neutral stimuli always occurred between the same valences of images, participants were expected to use the neutral images to predict the upcoming valence.

People who scored highly in the future factor of the ZTPI were expected to be the most likely group to form predictions. Although no direct measure of prediction was included in the present study, an increased use of prediction could be reflected in improved recognition performance, as a result of increased attention being given to the neutral stimuli. Prediction could also result in a closer association between neutral items and the emotions felt during the study phase, due to the neutral images being perceived as part of a predictable affective context.

Individual Differences

Personality

Individual differences in personality, as assessed by the BFAS-ON, were expected to interact with context to affect the manner in which participants processed the neutral stimuli. Participants who score highly on the neuroticism subset of the BFAS-ON were expected to rate more neutral stimuli as

negative relative to participants who rated lowly in this dimension. This result was expected because people high in neuroticism have been shown to both deeply process negative information and superficially process positive stimuli (Chan, Goodwin, & Harmer, 2007). Since people high in the volatility aspect of neuroticism have an anxious response to all negative stimuli, this group was expected to be especially affected by negative contexts, as reflected by neutral stimuli that had appeared next to negative images being rated negatively. Due to this group's hypervigilance for negative cues, neutral stimuli near negative images were also expected to be better recognized at test. In contrast to the vigilance seen in people high in volatility, people high in withdrawal show a general avoidance of all stimuli, regardless of valence. Due to this avoidance and the negative affect common in this group, people high in withdrawal were expected to rate neutral items more negatively than other participants, regardless of the neutral stimuli's context, and to associate the stimuli with negative emotions.

Conversely, participants who scored highly on the openness trait of the BFAS-ON were expected to show enhanced transfer of positive emotional valence to neutral stimuli. People who score highly on the openness scale have been shown to more fully process positive stimuli, as evidenced by increased amygdala activation in response to positive stimuli relative to neutral and negative stimuli. Additionally, people in this population show decreased activation to negative stimuli, as compared to more neurotic people (DeYoung, Peterson, & Higgins, 2005). Due to this preferential activation, people high in openness were expected to rate neutral items that were situated adjacent to positive stimuli as being positively valenced. They were also expected to have enhanced recognition for these stimuli and to associate them with positive emotions.

Time Perspective

The ZTPI was used as a measure of individual differences in time perspective. As previously mentioned, the ZTPI consists of five factors: past-positive, past-negative, present-hedonistic, present-fatalistic, and future. In this study, past-negative people were expected to exhibit a general

downward dampening in their emotion and valence responses. Conversely, we predicted people in the past-positive group to show a general bias toward positive evaluations of the characters.

Present-focused participants, those high in either present-hedonistic or present-fatalistic, were not expected to be heavily influenced by the valence that appeared after the presentation of the neutral stimulus. Due to this group's lack of concern about the future, their valence choices were expected to instead correspond primarily to the valence of the images that appeared before the neutral stimuli. As a result of their bias to focus on the present, present-focused people may not have worked as hard to form predictions during the study phase as other participants, which could result in decreased performance on the recognition task.

Unlike the present-focused participants, people who scored highly in the future factor were expected to devote significant attention to the valence of the images that appeared after each neutral stimulus. For example, if a character appeared after negative images but before positive images, these participants were expected to focus primarily on the positive images and, thus, rate the character positively. Additionally, since this group places an emphasis on anticipating outcomes, they were especially likely to invest effort into forming accurate predictions. This biased emphasis on prediction had the potential to manifest as improved recognition performance.

Experiment

Participants

161 students (ages 18 - 35) in an introductory psychology course, Psychology 1100, received partial course credit in exchange for participating in the study. Before participating in the study, in accordance with Institutional Review Board (IRB) guidelines, each participant gave informed consent after reading about the research and their rights as a participant. Once participants complete the consent form, they completed demographic information and the individual difference inventories on a computer.

Materials

Online versions of the BFAS-ON and the ZTPI were completed by the participants. The context images in the study were drawn from a subset of the International Affective Picture System (IAPS: Lang, Bradley, & Cuthbert, 1997). The group of images included negative and positive images selected and matched on normed ratings of arousal (MPos = 4.88, SDPos = 0.96; MNeg = 5.16, SDNeg = 0.86) and valence extremity (MPos = 2.07, SDPos = 0.32; MNeg = -1.85, SDNeg = 0.34).

The neutral images in this experiment were black Chinese characters. These characters were chosen as neutral stimuli since they do not vary in attributes such as color and are generally not familiar to Americans. All of the stimuli were presented in a random order to each participant.

Design

Study Phase

Once the individual difference inventories were completed, the experiment began with the study phase. During this phase, participants viewed eight blocks of images, each consisting of ten groups of context transitions. The groups of IAPS images, consisting of seven like-valenced images, i.e. all positive or all negative, were separated from each other by one Chinese character. An example of a negative-positive transition trial from the study phase can be seen in *Figure 1*.

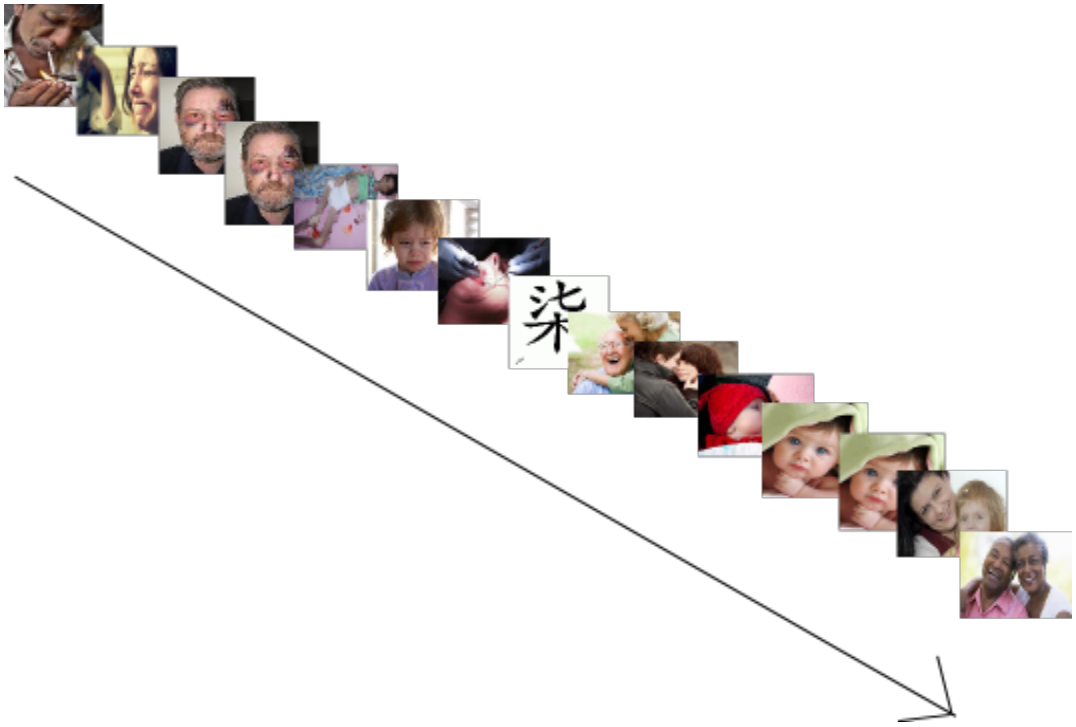

Figure 1. Negative-positive transition from study phase. This figure shows an example of the images that were used in this experiment and how they were presented.

Each block of the study phase included nine Chinese characters. Each character was repeated four times, thus allowing predictions to be formed. The characters were displayed for two seconds, while each IAPS image was shown for 750 ms. There was an interstimulus interval (ISI) of 500 ms, with a 300 ms jitter, between each image. A jitter is used to prevent participants from falling into a routine by slightly altering the length of the ISI between images. An ISI of 500 ms with a jitter of 300 ms means the amount of time between each image was between 200 and 800 ms. A check of attention was used during the study phase to ensure participants were viewing the screen. Participants were asked to press 'J' each time an IAPS image was immediately repeated.

Test Phase

In the test phase of this experiment, the Chinese characters were presented one at a time. The test phase was divided into three tasks: recognition, valence, and emotion. In each part of the test phase,

half the presented Chinese characters had been shown during the study phase; these characters are referred to as targets. The other half of the characters, referred to as lures, had not been previously presented. In each task, participants were presented with 24 lures and 24 targets. In the emotion task, the lures served as a baseline against which to measure participants' ratings of the targets. In the valence and the recognition tasks, characters from each of the transitions were compared to each other.

The amount of time participants were allotted to answer the test questions varied by task. Responses made after the time limit were still recorded but participants were shown the words 'Too Slow' to encourage them to respond more quickly. The words 'Too Slow' were displayed for 750 ms.

Recognition Task

During the recognition test, participants were asked whether or not they remembered seeing the characters before. Participants were given 1 second to respond to this question. See *Figure 2* for an example of a recognition question.

Do you remember this item?

J - old K - new

Figure 2. A sample recognition question from the test phase.

Valence Task

In the second part of the test phase, participants were asked to rate the valences of the Chinese characters. Participants were given 1.5 seconds to answer this question. An example of a valence question can be seen below in *Figure 3*.

Evaluate this image

D- very negative F - negative J - positive K - very positive

Figure 3. A sample valence question from the test phase.

Emotion Task

In the third section of the test, participants were asked to choose which emotion, hope, happy, sad, or anxiety, they associated with each character. Participants were given 1.5 seconds to answer this question. Before beginning this task, participants completed a practice block consisting of eight trials to allow them to become acquainted with the task and answer choices. *Figure 4* shows an example of an emotion question.

Choose the best fitting category:

D - anxiety F - sad J - happy K - hope

Figure 4. A sample emotion question from the test phase.

The response keys for the emotion and valence questions were counterbalanced, meaning half of the participants used the key options seen in the above figures while the keys used by the other half of the participants were reversed. For example, in the emotion task, half the participants instead used the keys 'J' and 'K' to indicate anxiety and sad, respectively, and D and F to indicate happy and hope, respectively. Counterbalancing is used to ensure participants responses are not due to variables such as keys on one

side of the keyboard being favored. In both the emotion and the valence tasks, answer choices associated with negativity were on one hand while those associated with positivity were on the other hand. This was held constant across these two tasks. For example, if a participant used ‘D’ and ‘F’ to indicate negative in the valence task, this participant would also use ‘D’ and ‘F’ to indicate negative emotions (anxiety and sad) in the emotion task.

After the recognition, emotion, and valences tasks were completed, participants knowledge concerning the Chinese characters presented during the experiment was assessed through the following question: "Did you know the meaning of any of the Chinese characters in this study? Press 'Y' for Yes or 'N' for No." Participants were also asked the following question: "Did you honestly put effort into this study? Your answer will NOT affect your credit. Press 'Y' for Yes or 'N' for No."

Results

Exclusions

The data of eight participants were excluded because the participants answered ‘yes’ to having knowledge of the meaning of the Chinese characters’ meanings. An additional thirteen participants who answered ‘no’ to having put forth effort were excluded. Ten participants were excluded due to technical issues with the experiment. Nine participants were excluded due to poor performance, defined as less than 75% accuracy, on the attentional task during the study phase. After these exclusions, 121 participants remained.

Analyses

The independent variables in this experiment were transition type, personality, and time perspective. The dependent variables were the participants’ responses during the three tasks of the test phase: recognition, valence, and emotion. The data was analyzed using R (R Development Core Team, 2009), the R packages lme4 (Bates & Maechler, 2009), and *languageR* (Baayen, 2009; cf. Baayen, 2008). Data was analyzed using linear mixed effect regression models to estimate p-values, which were

used to determine significance. Linear mixed effect regression models are used for continuous variables and produce t-statistics. We also used generalized linear mixed models, which estimated p-values via the Laplace approximation. Generalized linear mixed models are used for categorical data and produce z-statistics.

The use of mixed models is important since it does not ignore random differences that exist between stimuli and participants by treating these differences as random effects. When variables are included as random effects, they are assumed to have a normal distribution (Bates, 2012). Therefore, their variance does not contribute to whether or not a result is found to be significant. An example of a random effect in stimuli is that one stimulus may be inherently more recognizable than another. Likewise, one participant may be predisposed to naturally feel more strongly about a character than another participant. Isolating these differences as random effects reduces the likelihood of a Type 1 error, which refers to erroneously concluding a result is significant when it is not (Judd, Westfall, & Kenny, 2012).

In mixed models, independent variables are included as fixed effects. The variance of fixed effects, such as transition type and the individual difference measures, determines whether a result is found to be significant. Before mixed models were used, likelihood ratio tests were conducted to examine whether each fixed effect enhanced the model's ability to fit the data. This means, for each fixed effect, does it have a significant effect upon the dependent variable of interest, thus improving the model's ability to predict the data?

Recognition

Since recognition is a categorical variable, i.e. correct or incorrect, the recognition data was analyzed using generalized linear mixed models. The following model was used to determine whether recognition was affected by transition type:

$$\text{correct} \sim \text{transition} + (1 \mid \text{subject}) + (1 \mid \text{image})$$

In this model, whether or not characters were correctly recognized is the dependent variable of interest,

called correct. 'Transition,' the influence of transition type on recognition, is the fixed effect. 'Subject,' which refers to the different participants, and 'image,' which represents the different stimuli, are random effects. Including the fixed effect of transition type in the model did not improve the model's ability to fit the data, indicating transition alone did not significantly impact recognition performance, as shown by an insignificant likelihood ratio test ($p > 0.05$). Recognition performance was found to be near equal (53.3% - 53.9%) for all characters that participants had previously seen in the experiment (targets) but increased for characters that had not been previously presented (lures), ($M = 0.61$, $SE = 0.042$, $z = 10.39$, $p < 0.001$). This means participants were equally good at correctly identifying targets as old, regardless of transition type, but were better at identifying lures as new, as shown by *Figure 5*.

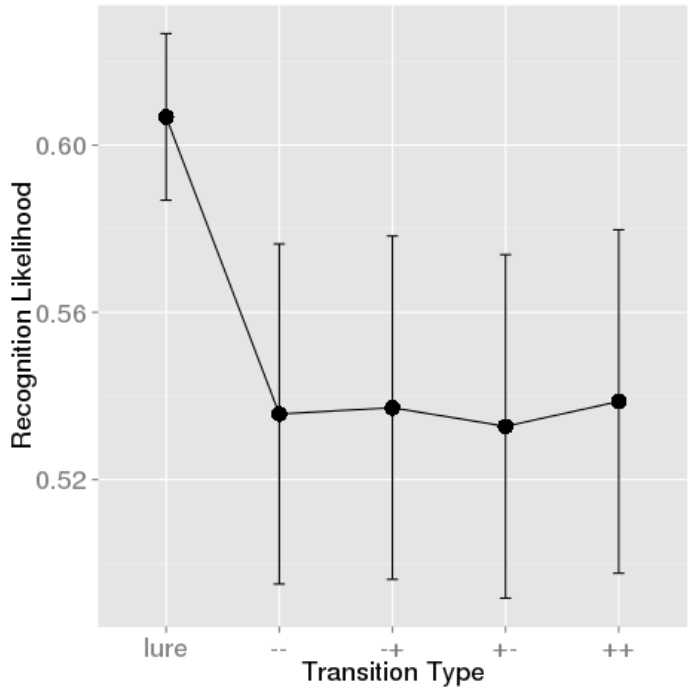

Figure 5. Recognition and transition type. Graph of recognition performance for characters that appeared in each of the transition types.

Personality differences were also not found to moderate recognition performance. The following model, which includes neuroticism, was not significantly better at accounting for the data than a model

without neuroticism ($p > 0.05$).

correct ~ transition * neuroticism_zscore_mean + (1 | subject) + (1 | image)

In this model, the fixed effects are transition type and level of neuroticism, while the random effects are participants and stimuli. Models similar to this one, in which the fixed effect of neuroticism was replaced with the other personality variables, also did not add value to the model without the fixed effect of personality ($p > 0.05$).

Next, we investigated the effect of time perspective on recognition. When present-fatalistic was included as a fixed effect in the model, as shown below, the model was significantly better able to fit the data ($p < 0.05$).

correct ~ transition * present_fatalistic_zscore_mean + (1 | subject) + (1 | image)

Participants who scored highly in the present-fatalistic subset of the ZTPI had better recognition for the positive-negative characters than the negative-negative characters ($M = 0.522$, $SE = 0.120$, $z = 2.018$, $p < 0.05$). The likelihood ratio tests of models including the remaining subsets of the ZTPI as fixed effects were not significant, meaning they did not improve the fit of the model ($p > 0.05$).

Valence

Valence ratings were quantified using a linear scale such that very positive = 3, positive = 1, negative = -1, and very negative = -3. This allowed valence to be treated as a continuous variable. Therefore, the valence data was analyzed using linear mixed effect regression models. Participants' valence judgments were significantly influenced by transition type, as evidenced by a significant likelihood ratio test comparing the model with transition type as a fixed effect to the model without transition type ($p < 0.01$). The model including transition as a fixed effect is shown below.

valence_score ~ transition + (1 | subject) + (1 | image)

Characters that appeared in the negative-positive ($M = 0.29$, $SE = 0.082$, $t = 3.26$ $p < 0.01$) and positive-positive ($M = 0.24$, $SE = 0.082$, $t = 2.72$ $p < 0.01$) transitions were rated more highly than the

lures, as shown by *Figure 6*.

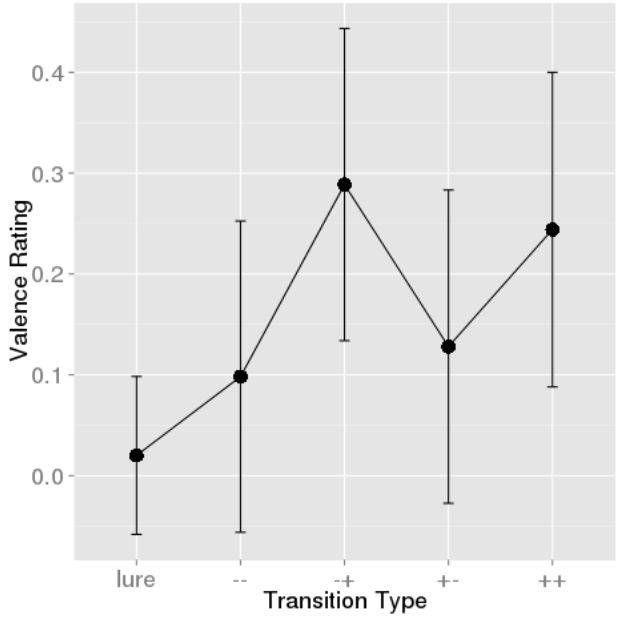

Figure 6. Valence ratings and transition type. Graph of valence ratings for characters that appeared in each of the transition types.

Lures were not rated significantly different from zero, indicating these stimuli were perceived as neutral. Only the positive-positive and negative-positive characters were rated significantly higher than the lures. This was our primary expected result since the neutral stimuli in both of these groups predicted positive images to come.

Models that included personality variables as fixed effects did not fit the data better than the original model without personality ($p > 0.05$). Therefore, personality differences did not moderate valence ratings.

With regard to time perspective, only the models that included the subsets present-hedonistic and present-fatalistic as fixed effects added value to the model ($p < 0.05$). The models are shown below.

valence_score ~ transition * present_hedonistic_zscore_mean + (1 | subject) + (1 | image)

valence_score ~ transition * present_fatalistic_zscore_mean + (1 | subject) + (1 | image)

People high in the present-hedonistic subset rated the positive-positive characters more highly than the lures ($M = 0.181$, $SE = 0.086$, $t = 2.11$, $p < 0.05$), as did participants who rated highly in the present-fatalistic subset ($M = 0.217$, $SE = 0.088$, $t = 2.45$, $p < 0.05$). The graphs of theses groups' valence ratings are shown in *Figure 7* and *Figure 8*, respectively. Although median splits are seen in the graphs of the data, the data is only divided in this manner for visualization purposes. Median splits were not a part of the analyses.

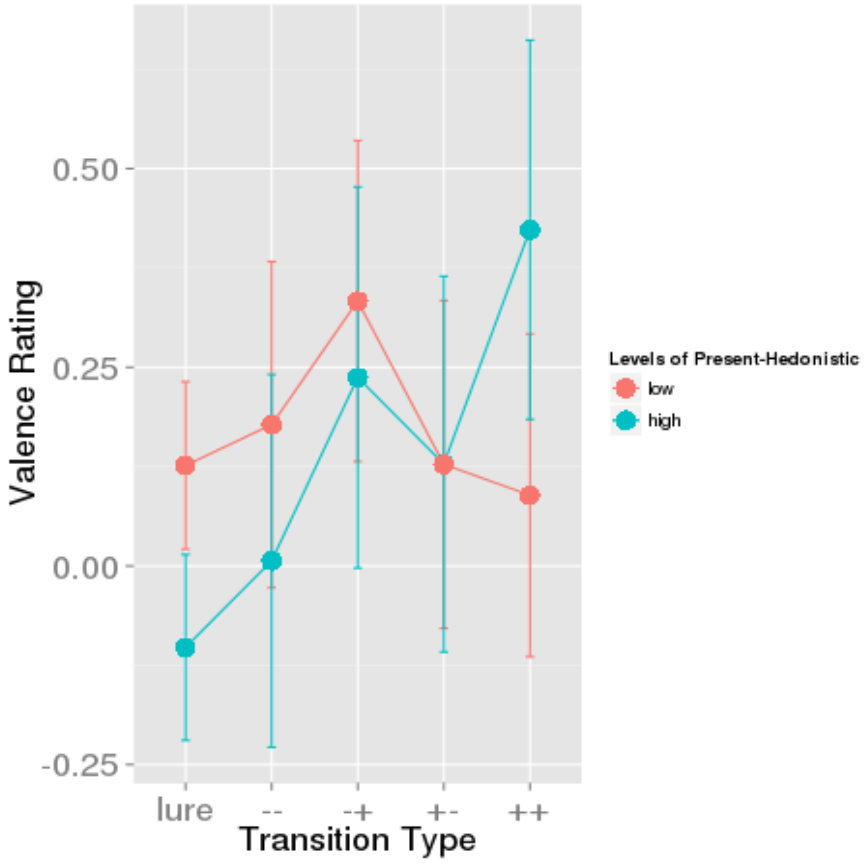

Figure 7. Valence ratings, transition type, and levels of present-hedonistic time perspective. Graph of valence ratings for characters that appeared in each of the transition types, as affected by having high or low levels of present-hedonistic time perspective.

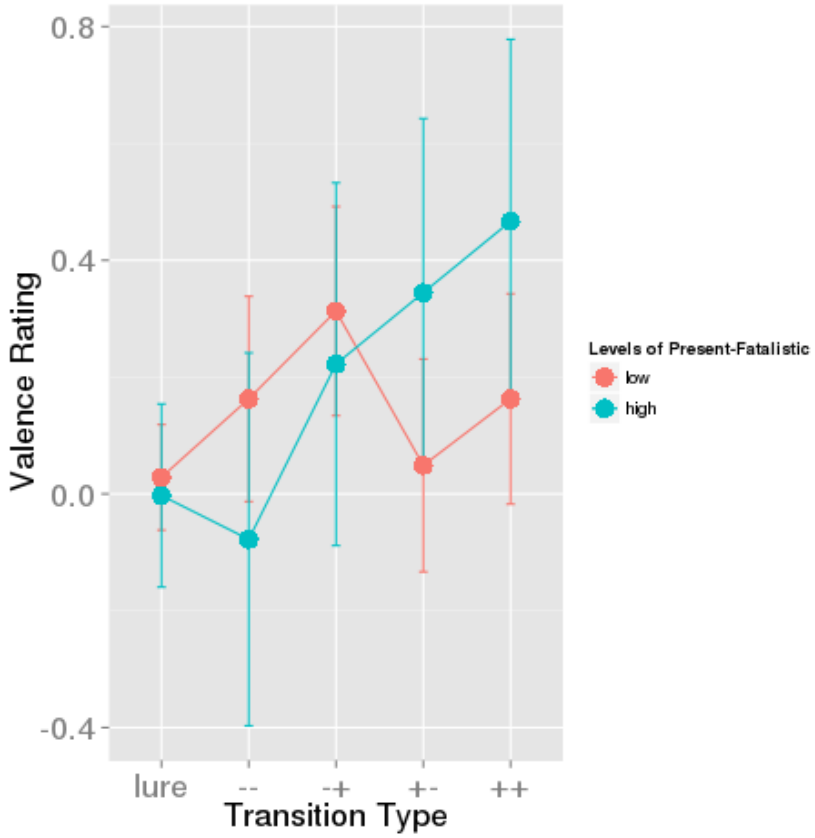

Figure 8. Valence ratings, transition type, and levels of present-fatalistic time perspective. Graph of valence ratings for characters that appeared in each of the transition types, as affected by having high or low levels of present-fatalistic time perspective.

Emotion

The emotion data consisted of the following categorical variables: happy, sad, hope, and anxiety. Therefore, it was analyzed using generalized linear mixed models. The results for each of these four categories are presented separately.

Hope:

Models that included the fixed effects of recognition performance, transition type, time perspective, and/or personality differences did not enhance the model's ability to fit the data, indicating participants ratings of hope were not affected by these independent variables ($p > 0.05$).

Happy:

Ratings of characters as happy were not affected by the fixed effect of transition type but were affected by recognition performance ($p < 0.05$). The model with recognition as a fixed effect is shown below.

$$happy \sim recog\_correct + (1 \mid subject) + (1 \mid image)$$

When participants had high recognition performance, they were more likely to rate characters as happy ($M = 0.383$, $SE = 0.088$, $z = 4.36$, $p < 0.001$). However, recognition did not interact with transition type. Neither personality nor time perspective moderated participants' ratings of characters as happy ($p > 0.05$).

Sad:

The use of the emotion rating sad was affected by transition type, as evidenced by a significant likelihood ratio test between the model with transition type as a fixed effect, as shown below, and the model without this fixed effect ($p < 0.05$).

$$sad \sim transition + (1 \mid subject) + (1 \mid image)$$

Participants were significantly less likely to rate characters as sad if they had been situated in a positive-positive transition rather than a negative-negative one, as shown by *Figure 9* ($M = 0.190$, $SE = 0.13$, $z = -2.87$, $p < 0.01$).

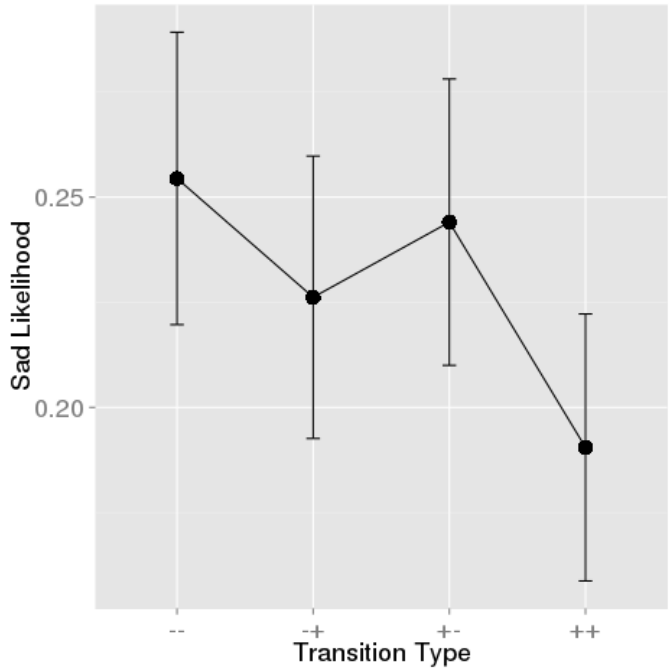

Figure 9. Sad and transition type. Graph of the use of the emotion sad for characters that appeared in each of the transition types.

Unlike transition type, neither personality nor recognition performance moderated the rating of characters as sad ($p > 0.05$).

With regard to time perspective, the models with present-hedonistic as a fixed effect, as shown below, enhanced the model's fit to the data ($p < 0.05$).

sad ~ transition * present_hedonistic_zscore_mean + (1 | subject) + (1 | image)

Participants high in the present-hedonistic subset of the ZTPI were less likely to associate sad with positive-negative characters, as compared to the negative-negative characters ($M = 0.261$, $SE = -0.28$, $z = 0.13$, $p < 0.05$). The model with past-positive as a fixed effect was also significantly better at fitting the data than the model without this fixed effect, as shown by a significant likelihood ratio test ($p < 0.05$).

sad ~ transition * past_positive_zscore_mean + (1 | subject) + (1 | image)

Participants high in the past-positive subset were more likely to use the description of sad for

negative-positive characters than negative-negative characters (M = 0.205, SE = 0.14, z = 1.99, p < 0.05). Additionally, the inclusion of the past-negative subset as a fixed effect improved the model (p < 0.05).

sad ~ transition * past_negative_zscore_mean + (1 | subject) + (1 | image)

Participants who scored highly in past-negative were more likely to rate both negative-positive (M = 0.214, SE = 0.15, z = 2.52, p < 0.05) and positive-negative characters (M = 0.231, SE = 0.15, z = 2.15, p < 0.05) as sad, as compared to the negative-negative characters. Models with the other two ZTPI subsets, future and present-fatalistic, as fixed effects were not significantly better at fitting the data than the model without a time perspective subset.

Anxiety:

With concern to anxiety, a model with transition as a fixed effect, as shown below, was better able to fit the data than a model without transition type (p < 0.05).

anxiety ~ transition + (1 | subject) + (1 | image)

Participants were significantly more likely to classify positive-negative characters as anxiety than negative-negative characters, as shown by *Figure 10* (M = 0.277, SE = 0.129, z = 2.001, p < 0.05).

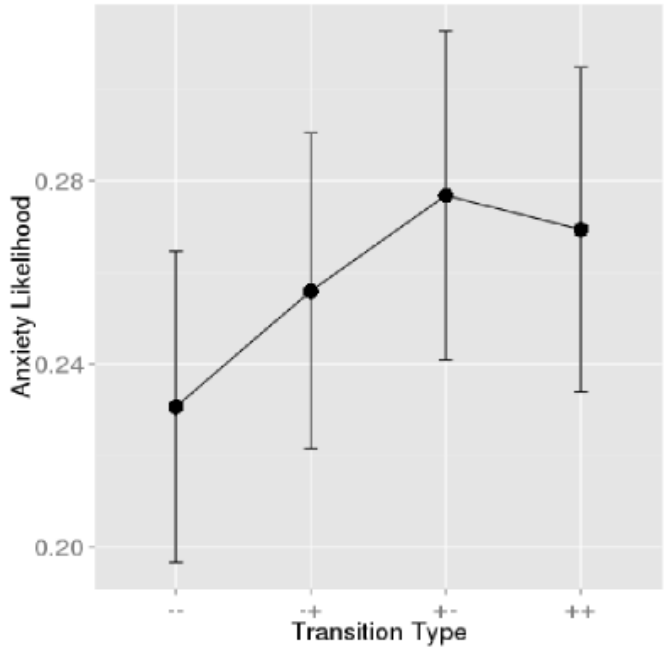

Figure 10. Anxiety and transition type. Graph of the use of the emotion anxiety for characters that appeared in each of the transition types.

The likelihood ratio test was also significant when recognition performance was added as a fixed effect in addition to transition type ($p < 0.05$).

anxiety ~ transition * recog_correct + (1 | subject) + (1 | image)

Participants were less likely to rate positive-positive items as anxiety if they had high recognition performance, which can be seen in *Figure 11* ($M = 0.227$, $SE = 0.26$, $z = -2.24$, $p < 0.05$). Individual differences, including personality and time perspective, did not moderate participants' ratings of characters as anxiety ($p > 0.05$).

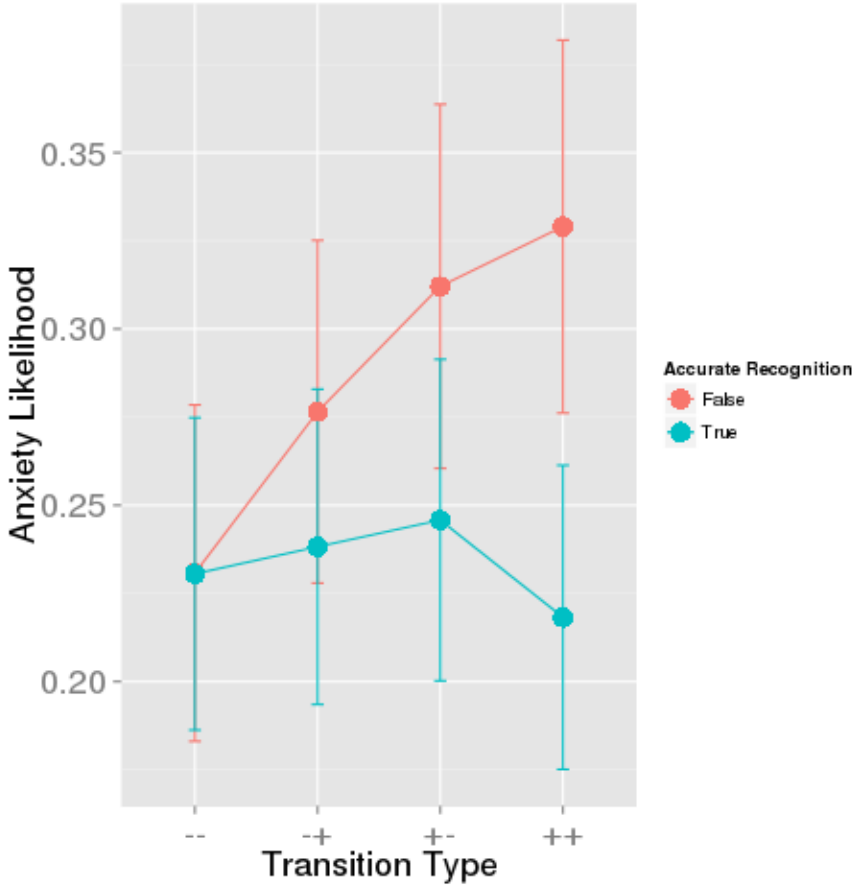

Figure 11. Anxiety, transition type, and recognition performance. Graph of the use of the emotion anxiety

for characters that appeared in each of the transition types, as affected by high or low levels of recognition accuracy.

Discussion

Overall, the results validated one of our principal hypotheses: neutral images that predicted positive images were rated more positively than other neutral images. This was true regardless of individual differences, indicating the prediction of positive future events imbues present neutral events with a positive valence for people of varying personalities and time perspective biases. Importantly, while the negative-positive stimuli were rated more highly than the lures, the positive-negative stimuli were not, despite the fact that these characters all appeared between a block of positive images and a block of negative ones. Therefore, contiguity of stimuli was not driving the elevated valence ratings of the negative-positive stimuli. Instead, this effect was due to the transition from a stream of negative images to one of positive images.

In addition to transition type, time perspective also influenced valence ratings. People high in the present-hedonistic or present-fatalistic subsets rated the positive-positive characters more highly than the lures. The present-focused nature of these participants' time perspective biases may have led them to attend more highly to the positive information that was being presented to them in the moment, thus leading them to rate these stimuli positively.

The influence of time perspective was also evident in the effect of the present-fatalistic subset of the ZTPI on recognition data. As aforementioned, people who score highly in this aspect of the scale are biased to focus on the present moment. They do not try to predict the future since they view it as an unchangeable event that will occur regardless of their predictions (Zimbardo & Boyd, 1999). The improved recognition in this group for the positive-negative characters as compared to the negative-negative characters could indicate that a present positive emotion enhances memory in this population. However, it is unclear why this effect would not also be present for the positive-positive

characters if only the emotion present before the characters affected recognition performance. Therefore, people in this group may have only chosen to preferentially focus on the positive images appearing before the neutral characters when they suspected negative images might be next.

Although recognition performance was affected by time perspective, it was not affected by transition type nor personality as was expected. Although participants showed increased recognition for lures, as compared to targets, their performance for targets was near equal performance across transition types. This result indicates their learning was not affected by the emotional trajectories in which the targets were situated. While emotional context affected how stimuli were remembered, as evidenced by the valence data, it did not influence whether they were remembered.

However, whether the characters were remembered did affect the emotion with which they were later associated. Recognition performance influenced the emotions associated with the neutral characters, indicating the strength of our memory for neutral events affects the manner in which we recall those events. In addition to recognition performance, transition type and time perspective each had a significant impact upon participants' use of the emotion sad but not the other emotion categories, indicating the emotion sad is most affected by context. Neutral events situated between positive events were unlikely to be rated as sad, since they were unlikely to be associated with negative images.

With regard to time perspective, people high in present-hedonistic exhibited a decreased use of sad to describe positive-negative characters. Since people high in present-hedonistic tend to focus on pleasure in the current moment, this reflects their tendency to preferentially focus on the positive present rather than the negative prediction of the future. Additionally, people high in past-negative were more likely to rate negative-positive and positive-negative characters as sad than the negative-negative characters. This group of people may be more sensitive to the type of context, rather than the transition trajectory, than other participants, leading them to rate characters as sad if both a negative and positive context appeared adjacent to the characters.

The finding that people were more likely to rate positive-negative characters as anxiety supports our hypothesis because these characters predicted the appearance of negative stimuli, which would have caused the participants to feel anxiety. Additionally, the results indicate that when participants remembered the characters, as shown by high recognition performance, they were more likely to rate positive-negative characters as anxiety. It has been shown by Dolan that when people have robust memories of the stimuli being used to make predictions, they have an enhanced ability to make accurate predictions (2002). The participants who had a strong memory of the characters were therefore likely better at using these characters to make predictions. Therefore, when the positive-negative characters appeared, they would be better able to predict the upcoming negative stimuli, thus causing them to associate the emotion of anxiety with these characters.

Future Directions

Questions that still remain to be answered include how other personality variables and individual differences affect the processing of neutral stimuli situated in emotional contexts. Of particular clinical interest is further investigation of the attentional biases in people with mood and/or anxiety disorders. It would be interesting to investigate differences between people with different scores on inventories of depression, such as the Beck Depression Inventory-II (BDI-II: Beck, Steer, & Brown, 1993). Along the same line, the Subjective Happiness Scale could provide insight into how levels of happiness affected stimuli processing (SHS: Lyubomirsky & Lepper, 1999).

In future work, another possible change would be to use the extraversion subset of the BFAS rather than openness. While openness has been shown to correlate with measures of happiness, extraversion shows a more broad and robust correlation. In fact, “happiness is one of the strongest correlates of extraversion” (Argyle & Lu, 1990b, p. 1011). The subsets of extraversion, enthusiasm and assertiveness, are both positively correlated with items such as positive emotions and friendliness (DeYoung,et al., 2007). While openness is a measure of intellectual curiosity, extraversion is one of social

skills, which are linked with happiness (Argyle & Lu, 1990a). Therefore, extraversion may have been a more appropriate personality variable for assessing the differences in more and less happy people.

In addition to individual differences in personality, a wide variety of other individual differences could be assessed, including levels of cognitive reappraisal and working memory capacity. It is key for future work to include measures of individual differences since people do vary in tangible ways that impact the how we perceive the world. Additionally, it is critical for future studies to strive to create emotions in participants through contextual presentations of stimuli, since emotion is a product of more than one single instance in time. Through future work, we will continue to learn of the importance of interactions between prediction, context, and individual differences in shaping memory.

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Appendix A

Big Five Aspect Scale- Openness and Neuroticism (BFAS-ON)

Here are a number of characteristics that may or may not describe you. For example, do you agree that you seldom feel blue? Please fill in the number that best indicates the extent to which you agree or disagree with each statement below. Be as honest as possible, but rely on your initial feeling and do not think too much about each item.

Use the following scale:

1 - - - - - - - - 2 - - - - - - - - 3 - - - - - - - - 4 - - - - - - - - 5

Strongly	**Neither Agree**	**Strongly**
Disagree	**Nor Disagree**	**Agree**

Seldom feel blue

Am quick to understand things

Get angry easily

Have difficulty understanding abstract ideas

Enjoy the beauty of nature

Am filled with doubts about things

Rarely get irritated

Believe in the importance of art

Feel comfortable with myself

Can handle a lot of information

Get upset easily

Love to reflect on things

Feel threatened easily

Like to solve complex problems

Keep my emotions under control

Get deeply immersed in music

Rarely feel depressed

Avoid philosophical discussions

Change my mood a lot

Do not like poetry

Worry about things

Avoid difficult reading material

Rarely lose my composure

Seldom notice the emotional aspects of paintings and pictures

Am easily discouraged

Have a rich vocabulary

Am a person whose moods go up and down easily

Need a creative outlet

Am not embarrassed easily

Think quickly

Am not easily annoyed

Seldom get lost in thought

Become overwhelmed by events

Learn things slowly

Get easily agitated

Seldom daydream

Am afraid of many things

Formulate ideas clearly

Can be stirred up easily

See beauty in things that others might not notice

Appendix B

Zimbardo Time Perspective Inventory (ZTPI)

For the following questions, read each item and, as honestly as you can, answer the question: "How characteristic or true is this of you?" Choose the appropriate answer using the scale.

1 = very untrue 2 = untrue 3 = neutral 4 = true 5 = very true

Happy memories of good times spring readily to mind.

It is important to put excitement in my life.

I think about good things that I have missed out on in my life. It doesn't make any sense to worry about the future since there is nothing that I can do about it anyway.

I complete projects on time by making steady progress.

I take risks to put excitement in my life.

I am able to resist temptations when I know there is work to be done.

I find myself getting swept up in the excitement of the moment.

I think about the bad things that have happened to me in the past.

It takes joy out of the process and flow of my activities if I have to think about goals, outcomes, and products.

Familiar childhood sights, sounds, and smells often bring back a flood of wonderful memories.

I often think of what I should have done differently in my life.

It gives me pleasure to think about my past.

When I want to achieve something, I set goals and consider specific means for reaching those goals.

Since whatever will be will be, it doesn't really matter what I do.